Guideline No.: E-07(~~201909~~2022~~XX~~08)

E-07

TRANSFORMERS

Issued date: ~~September~~ 25, ~~19~~08, ~~2019~~2022

Foreword

CCS Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.

This Guideline frees the users to adopt other test methods and requirements which are equivalent to or are stricter than this Guideline.

This Guideline is published and updated by CCS, and is released at http://www.ccs.org.cn. Your comments or suggestions are welcomed and may be sent to our email addressed mp@ccs.org.cn.

Historical versions and release date : E-07(201510) October 20,2015

E-07(201610) October 28,2016

E-07(201705) May 9,2017

E-07(201712) December 26, 2017

E-07(201909) September 19, 2019

Main changes:

1. Update the version number of the reference standard

~~1. IEC60076-3 (2013-07) replaced by IEC60076-3 (2018-03)~~

2. The names and definitions in the modification guide are consistent with the specifications and reference standards~~IEC60076-11 (2004-05) replaced by IEC60076-11 (2018-08)~~

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TRANSFORMERS

1 Application

1.1 This Chapter applies to approval and inspection of transformers for power and lighting (including single phase transformers rated at 1 kVA or more and three-phase transformers rated at 5 kVA or more) installed and used on ships and offshore installations. Instrument transformer and auto-transformer can be implemented by reference.

2 Normative references

2.1 The approval and inspection of transformers in this Chapter are to be based on the following documents:

(1) IEC 60092-303(1980-1) Electrical installations in ships – Part 303: Equipment - Transformers for power and lighting

(2) IEC 60092-303-am1 (1997-9) Amendment 1-Electrical installations in ships – Part 303: Equipment - Transformers for power and lighting

(3) IEC 60076-1(2011-04) Power transformers – Part 1: General

(4) IEC 60076-2(2011-02) Power transformers – Part 2: Temperature rise for liquid-immersed transformers

(5) IEC 60076-3(2018-03) Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air

(6) IEC 60076-4(2002-06) Power transformers – Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors

(7) IEC 60076-5(2006-02) Power transformers – Part 5: Ability to withstand short circuit

(8) IEC 60076-10: (2016-03) Power transformers – Part 10: Determination of sound levels

(9) IEC 60076-10-1: (2016-03) Power transformers – Part 10-1: Determination of sound levels - Application guide

(10) IEC 60076-11(2018-08) Power transformers – Part 11: Dry-type transformers

(11) IEC 60076-12: (2008-11) Loading guide for dry-type power transformers

(12) IEC 60529 (2013-08) Degrees of protection provided by enclosures (IP Code)

(13) IEC 60068-2-30(2005-08) testing – Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)

(14) IEC 60068-2-11(~~1981-01~~2021) Environmental testing – Part 2: Tests - Test Ka: Salt mist

(15) CCS Rules for Classification of Sea-going Steel Ships, and its amendments

(16) Guideline on Type Approval Test of Electrical and Electronic Products (current valid version)

3 Terms and definitions

3.1 The terms and definitions used in this Chapter are consistent with those of IEC 60076.

4 Plans and documents

4.1 The following plans and documents are to be submitted to CCS for approval:

(1) General plans;

(2) Drawings of main parts including frame, cliquids, iron cores, terminal boxes, enclosures (if applicable);

(3) Technical specifications of the products;

(4) Type test programme.

4.2 The following plans and documents are to be submitted to CCS for information:

(1) Operation instructions for the products;

(2) Process flow diagram indicating quality control points;

(3) Documents of manufacturing procedures, covering winding, sheet metal processing,

painting (if applicable), lamination, insertion, vacuum dipping coating (if applicable), drying (if applicable), welding, polyester casting (if applicable) and various calculation sheets (tables);

(4) List of types (trade marks) and suppliers of main raw materials (e.g. magnetic wires, silicon steel sheets, insulation paper and insulating paints);

(5) Drawing of external wiring.

5 Design and technical requirements

5.1 Marine transformers are to comply with IEC 60092-303 and in addition, the following requirements:

5.1.1 All transformers, except those used for motor starting, are to be double wound or have multiple windings, with no electrical connections between primary and secondary windings.

5.1.2 In general, transformers are to be of dry, air-cooled type. ~~Proposals for the use of liquid-filled transformers are to comply with the following requirements:~~

~~(1) Cooling fluids are to be non-toxic and of low flammability. Liquid-filled transformers are to be provided with a pressure release device with alarms and there is to be a suitable means provided to contain any liquid which may leak from the system due to the release of alarms or breakage of transformers;~~

~~(2) Where forced cooling is used, there is to be temperature monitoring of the heated cooling medium and cliquids with an alarm being given when the temperature exceeds a preset value which can be recovered by reducing load.~~

5.1.3 The ~~voltage drop (~~voltage regulation~~)~~, Temperature rise, Short-circuit shall comply with the requirements of Chapter 3, Part Four of China Classification Society Rules for Classification of Sea-going Steel Ships. ~~in the secondary voltage between no load and rated load, under resistive load, is not to exceed the following:~~

~~(1) 2.5% for single phase transformers rated more than 5 kVA or 3 phase transformers rated more than 15 kVA;~~

~~(2) 5% for single phase transformers rated up to 5 kVA or 3 phase transformers rated up to 15 kVA.~~

~~5.1.4 Transformers arranged for parallel operation are to comply with the following~~

requirements:

(1) their winding connections are to be compatible;

(2) their rated voltage ratios are to be equal (with tolerances within permissible limits);

(3) their short-circuit impedance values are to be equal (if expressed in percentage, a ratio within 0.9 to 1.1 may be allowed);

(4) when transformers are intended for operation in parallel, the rated output of the smallest transformer in the group is not be less than 50% of the rated output of the largest transformer in the group.

5.1.5 The temperature rise of transformers at any part is not to exceed the values given in Table 5.1.5 during continuous operation at rated output, where the ambient air temperature is based on 45°C.

Limit of Temperature Rise **Table 5.1.5**

Transformer type	Temperature rise limit of windings (K)		Method of measurement
Dry type	Class A insulation Windings	55	Resistance method
	Class E insulation Windings	70	
	Class B insulation Windings	75	
	Class F insulation Windings	95	
	Class H insulation Windings	120	
	External surface of the magnetic core and structural components	Not to exceed the permissible temperature rise of the insulating material in contact	Thermometer or thermocouple
Liquid-filled transformers	Defined as ON or OF in IEC60092-303	65	Thermometer or thermocouple method
	Defined as OD in IEC60092-303	70	

5.1.6 All transformers are to be capable of withstanding, without damage, the thermal and mechanical effects of a short-circuit at the terminals of any windings for 2 s.

5.1.7 Transformers are to be subjected to high voltage test by applying a test voltage between primary and secondary windings and between windings and the frame. The test is to be made according to Table 5.1.7 and maintained for 1 min without breakdown and flashover.

~~Voltage of High Voltage Test~~ ~~Table 5.1.7~~

~~Maximum voltage (root mean square value) kV~~	~~Rated short-time withstand voltage (root mean square value) kV~~
~~≤ 1.1~~	~~3~~
~~3.6~~	~~10~~
~~7.2~~	~~20~~
~~12.0~~	~~28~~
~~17.5~~	~~38~~
~~24.0~~	~~50~~
~~36.0~~	~~70~~

~~5.1.8 Transformers are to withstand an induced high voltage test with a voltage twice the rated voltage and the duration of the test is to be 1 min for a frequency less than or equal to twice the rated frequency, or t (t = 60 × 2 × rated frequency/test frequency (s)), but not less than 15 s for an increased frequency greater than twice the rated frequency. For transformers subject to temperature rise test, the induced high voltage test is to be carried out immediately after the temperature rise test.~~

5.1.~~9~~4 Proper terminals and clear marks should be provided for outside wirings. The terminals should be protected and isolated from each other to avoid accidental grounding, short circuit or being touched.

5.1.~~10~~5 Transformers should have a grounding terminal for protection use. All the metal parts which are not electrically charged should have structural method to be connected to the grounding terminal.

5.2 Marine transformers with metal enclosures are to comply with the above-mentioned standards an in addition, the following requirements.

5.2.1 Metal enclosures are to be of sufficient mechanical strength for mechanical protection, normal operation and safe handling of transformers.

5.2.2 Metal enclosures are to have sufficient space to maintain enough air clearance and creepage distance between conducting parts and between conducting parts and non-conducting parts of transformers inside metal enclosures. When a transformer mounted in the metal enclosure is in normal operation, the temperature rise is to comply with the requirements of Chapter 3, Part Four of China Classification Society Rules for Classification of Sea-going Steel Ships~~Table 5.1.5 for Classification of Sea-going Steel Ships~~.

5.2.3 Degree of protection provided by metal enclosures is to be appropriate to the ambient conditions of the location where transformers are installed.

~~5.3~~ For transformers with voltage rating higher than 1kV, following requirements are to be complied with:

~~5.3.1~~ The enclosure protection class should be at least IP23. If installed in locations which can be accessed by unprofessional personnel, the enclosure protection class should be at least IP4X, the installation should comply with CCS Rules Part Four 2.14.7.1.

~~5.3.2 Dry-type transformers should comply with acceptable standards (See IEC60076-11 Dry-type transformers or other equivalent standards), Liquid-filled transformers should also comply with acceptable standards (See IEC60076 power transformers or other equivalent standards).~~

5.3~~.3~~ Liquid filled transformers should have ~~following~~ alarms and protections to meet the requirements of Section 2.14.4.2 of Chapter 2, Part Four of China Classification Society Rules for Classification of Sea-going Steel Ships.~~:~~

~~(1) Low liquid level alarm;~~

~~(2) High liquid temperature alarm;~~

~~(3) Low liquid level tripping or load decrease;~~

~~(4) High liquid temperature tripping or load decrease;~~

~~(5) High air pressure relay tripping.~~

6 Materials and components

6.1 Materials and components should be controlled by the relevant requirements of CCS current rules.

6.2 Shall be included in the list of eligible suppliers, The list of manufacturer for the following materials and components of the product should not be changed without the Society's approval: Silicon steel sheet, copper wire / aluminum wire / copper fliquid / aluminum fliquid.

7 Type test

Marine transformers are to be subjected to type test according to the following requirements.

7.1 Unless otherwise specified,all tests shall be carried out under environmental conditions of 5℃ ~ 40℃.

7.2 Type test of marine transformers is at least to be in accordance with Table 7.2.

Type Test Items **Table 7.2**

No.	Test item	Technical requirements	Test method
1.	Exterior inspection		Visual inspection
2.	Measurement of winding resistance	IEC 60076-1 para. 11.2	IEC 60076-1 para. 11.2
3.	Measurement of voltage ratio and check of phase displacement	IEC 60076-1 para. 11.3	IEC 60076-1 para. 11.3
4.	Measurement of no-load loss and current	IEC 60076-1 para. 11.5	IEC 60076-1 para. 11.5
5.	Measurement of short-circuit impedance and load loss	IEC 60076-1 para. 11.4	IEC 60076-1 para. 11.4

~~**Continued Table 7.2**~~

6.	Applied Voltage test	3.6.6.3, Chapter 3, PART FOUR of CCS Rules	IEC 60076-3 para.10
7.	Induced voltage withstand test	3.6.6.4, Chapter 3, PART FOUR of CCS Rules	IEC 60076-3 para. 11
8.	Insulation resistance test	3.6.7.5, Chapter 3, PART FOUR of CCS Rules	3.6.7.5, Chapter 3, PART FOUR of CCS Rules
9.	Lightning impulse test (applicable for Um> 3.6 kV dry-type)	IEC 60076-11 para. 14.3.1	IEC 60076-3 para. 13
10.	Partial discharge measurement (applicable for Um> 3.6 kV dry-type)	IEC 60076-11 para. 14.2.7	IEC60270, IEC60076-3Appendix A
11	Sound level measurement(For dry-type transformers only when required by the custome)	IEC 60076-10	IEC 60076-10
12	Voltage regulation test(may be omitted when impractical at the manufacturer, subject to agreement of CCS)	3.6.3.1, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships	3.6.7.6, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships
13	Short-circuit test(For dry-type transformers only when required by the custome)	3.6.6.7, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships	IEC 60076-5
14	Temperature rise	3.6.6.2, Chapter 3, PART FOUR of CCS Rules	IEC60076-2(for Liquid-filled), IEC60076-11 para.14.3.2(for dry-type)
15	Damp heat test	CCS Guidelines for Type Approval Test of Electric and Electronic Products (current valid version) 2.10, 6 period	IEC 60068-2-30
16	Enclosure test (for transformers with enclosures)	IEC 60529	IEC 60529

17	Salt mist test Ka (for open deck)	CCS Guidelines for Type Approval Test of Electric and Electronic Products (current valid version) 2.13	IEC 60068-2-11
18	Function test of components (If applicable, PT100, cooling fans, protection devices, etc.)		

7.3 Selection of typical samples

7.3.1 Type test samples are to be taken from qualified products by CCS Surveyor at the manufacturer.

7.3.2 In the case of initial type approval At least one marine transformer is to be taken as test sample (more may be taken if necessary), if the capacity of the product applying for approval is not larger than 200kVA, the capacity of which is to be the maximum in the products to be approved. If the capacity of the product applying for approval is larger than 200kVA, then the test sample can be chose between range 50%~100%, but it is needed to confirm that the manufacturer has the ability to produce the maximum capacity. Where different insulation levels and constructions are to be covered by approval, related products are to be sampled respectively.

7.3.~~4—~~3 If environmental tests are restricted by test equipment (such as damp heat test), a smaller transformer of the same type may be taken as test sample.

7.4 Test organization

7.4.1 In the case of type approval, the type test shall generally be carried out at an CCS-approved testing agency. If the equipment manufacturing plant has a standard test environment, test equipment and suitable inspection personnel, with the consent of the CCS, the type test may be carried out in the laboratory of the manufacturing plant and witnessed by the CCS surveyor on the spot.

8 Unit/batch inspection

8.1 Transformer rated at 50kVA and above,The manufacturers holding a CCS Type Approval B Certificate are still to carry out unit/batch inspection for all transformers and submit relevant certification documents and test reports.

8.2 Transformer rated at 50kVA and above~~For 50kVA and above transformers~~,the unit/batch inspection is required.The number of transformers to be inspected by CCS is to be 10% of the total number of submitted ones, but not less than 2 sets, unless the inspection is requested for one transformer only .Unit/batch inspection items are at least to include items:

(1) visual examination and processing examination (visual);

(2) measurement of winding resistance (IEC60076-1 para.11.2);

(3) measurement of voltage ratio and check of phase displacement (if applicable) (IEC 60076-1 para. 11.3);

(4) measurement of short-circuit impedance and load loss (IEC 60076-1 para. 11.4);

(5) measurement of no-load loss and no-load current (IEC 60076-1 para. 11.5);

(6) applied voltage test (IEC 60076-3 para. 11);

(7) induced voltage withstand test (IEC 60076-3 para. 12.2.1);

(8) measurement of insulation resistance (3.6.6.5, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships);

(9) partial discharge test (for Um ≥ 3.6 kV dry-type) (IEC60076-11 para. 14.2.7);

(10) voltage regulation test (may be omitted when impractical at the manufacturer, subject to agreement of CCS) (3.6.6.6, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships);

(11) temperature rise test (may be required only for the first product of batch products of the same type) (3.6.6.1~3.6.6.2, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships).

(12) function test of components(If applicable, PT100, cooling fans, protection devices, etc.).